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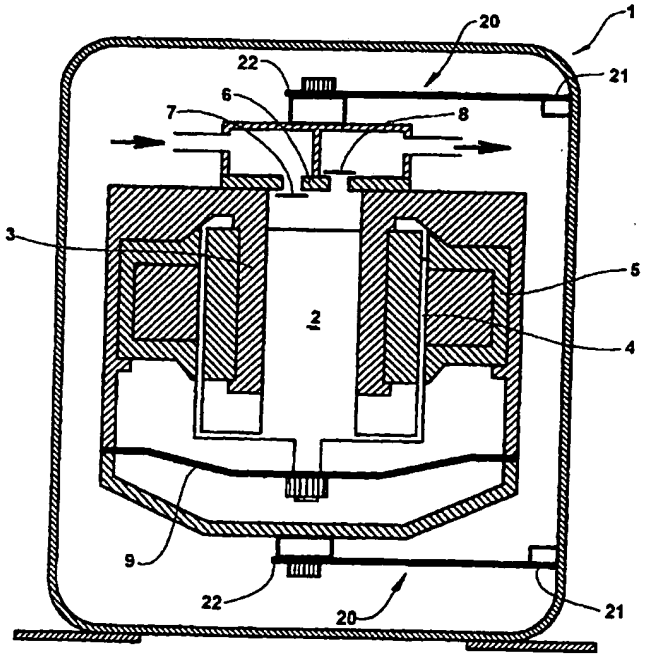
(54) Title: A RECIPROCATING COMPRESSOR DRIVEN BY A LINEAR MOTOR

(57) Abstract

A reciprocating compressor driven by a linear motor, having a motor-compressor assembly, which is mounted suspended inside a hermetic shell (1) and includes a piston (2) reciprocating inside a cylinder (3) and comprising at least two suspension arms (20), mounted to the hermetic shell (1) and to the cylinder (3) and provided spaced form each other and transversal in relation to the travel direction of the piston, each suspension arm (20) having, in the travel direction of the piston (2), enough flexibility to minimize the transference of vibrations from the motor-compressor assembly to the hermetic shell (1) and, in the directions transversal to said travel direction of the piston (2), enough rigidity to avoid oscillations of the motor-compressor assembly in said transversal directions.



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# A RECIPROCATING COMPRESSOR DRIVEN BY A LINEAR MOTOR

## Field of the Invention

The present invention refers to a suspension system for mounting a motor-compressor assembly inside a hermetic shell and to be applied to a reciprocating compressor driven by a linear motor and of the type used in small refrigerating appliances, such as refrigerators, freezers, drinking fountains, etc.

## Background of the Invention

In reciprocating compressors with a linear motor, the gas compression mechanism occurs by the axial movement of approximation and separation of a piston inside a cylinder, in relation to a cylinder head, which is mounted to an end of the cylinder and where suction and discharge valves are provided for regulating the admission and discharge of the gas in relation to the cylinder.

The piston is driven by an actuator, which sustains a magnetic component actuated by the linear motor. The piston is connected to a resonant spring, with which it forms, together with the magnetic component, the resonant assembly of the compressor.

This resonant assembly has the function of developing a linear reciprocating movement, making the movement of the piston inside the cylinder exert a compression action on the gas admitted by the suction valve, until said gas is discharged to the high pressure side of the refrigeration system to which the compressor is mounted.

In a known construction (figure 1), the motor-compressor assembly is mounted inside a hermetic shell on suspension springs provided therewithin. These suspension springs minimize the transmission of vibration from the motor-compressor assembly to the

hermetic shell. Such vibration is generated by the reciprocating movement of the resonant assembly in relation to the motor and has a preferential direction, being more intense in the direction of the reciprocating movement and less intense in both directions orthogonal to said direction of reciprocating movement.

One of the ways for minimizing the transmission of vibration in this construction is by obtaining an adequate reduction in the axial rigidity of the springs, which permits to achieve acceptable levels of vibration for the operation of the compressor. However, this solution has the following inconvenience: when the axial rigidity of the suspension springs is reduced, in the case of the helical springs commonly used and mounted parallel to the travel direction of the piston, the rigidity in both directions orthogonal to said travel direction is also reduced. Thus, by action of its weight, the whole motor-compressor assembly may fall to either side, causing impacts against the shell, resulting in other operational problems to the compressor. To minimize this oscillation, it is necessary to use upper springs, which are mounted inside the cover of the shell, which makes difficult to mount the compressor.

In another solution known in the art (US5772410), the motor-compressor assembly is mounted to the hermetic shell through suspension spring assemblies, whose axes are transversal to the direction of the reciprocating movement.

While this solution allows obtaining acceptable results in dampening the vibration and reducing the oscillation, it requires a spring assembly, which is complex and expensive to mount.

## Disclosure of the Invention

Thus, it is an objective of the present invention to provide a reciprocating compressor driven by a linear motor, having a suspension system which is easy to construct and mount and of low cost and which may absorb vibrations to the shell, minimizing the transmission of transversal oscillations of the motor-compressor assembly in relation to the travel direction of the piston, without impairing the rigidity thereof in its direction of reciprocating movement.

This and other objectives are attained by a reciprocating compressor driven by a linear motor, having a motor-compressor assembly, which is mounted suspended inside a hermetic shell and includes a piston reciprocating inside a cylinder and actuated by an actuator which sustains a magnetic component actuated by the linear motor, said compressor comprising at least two suspension arms, mounted to the hermetic shell and to the cylinder and provided spaced from each other and transversal in relation to the travel direction of the piston, each suspension arm having, in the travel direction of the piston, enough flexibility to minimize the transference of vibrations from the motor-compressor assembly to the hermetic shell and, in the directions transversal to said travel direction of the piston, enough rigidity to avoid oscillations of the motor-compressor assembly in said transversal directions.

Brief Description of the Drawings

The invention will be described below, with reference to the appended drawings, in which:

Figure 1 shows, schematically, a longitudinal diametrical sectional view of part of a reciprocating compressor with a linear motor, constructed according to the prior art;

Figure 2 shows, schematically, a longitudinal diametrical sectional view of part of a reciprocating compressor with a linear motor, constructed according to the present invention; and

Figure 3 shows, in a schematic perspective view, a constructive form of a suspension plate of the present invention.

Best Mode of Carrying Out the Invention

The present invention will be described in relation to a reciprocating compressor used in refrigeration systems and driven by a linear motor, this motor-compressor assembly being mounted inside a hermetic shell 1, which connects the compressor to a refrigeration system, for example.

In the illustrated construction, the compressor has a piston 2 provided inside a cylinder 3 and coupled to an actuating means 4, which is usually tubular, external to the cylinder 3 and sustains a magnetic component 5, which is axially impelled upon energization of the linear motor.

The separation and approximation movements of the piston 2 inside the cylinder 4 in relation to a cylinder head 6 mounted to an end of the cylinder 4 determines, respectively, the suction and compression operations of the gas in the compressor.

In the cylinder head 6 is provided a suction orifice, where is mounted a suction valve 7, and a discharge orifice, where is mounted a discharge valve 8, which valves regulate the admission and discharge of the gas in relation to the cylinder 3.

Piston 2 is connected to a resonant spring 9 and forms with the latter and with the magnetic component 5 a resonant assembly.

In the prior art construction in which the compressor is driven by a linear motor, as illustrated in figure

1, the motor-compressor assembly is suspended inside the hermetic shell 1 by suspension means in the form of helical springs 10, which are placed at the lower part of the inside of the hermetic shell 1. This construction has the deficiencies discussed above.

According to the present invention, the mounting of the motor-compressor assembly inside the hermetic shell 1 occurs through a suspension means comprising at least two suspension arms 20 mounted to both the hermetic shell 1 and to the cylinder 3, transversally to the travel direction of the piston 2, and spaced from each other, in said direction, by a distance sufficient to avoid that regions of the motor-compressor assembly external to the suspension arms 20 be subjected, upon movement of the piston 2 in the cylinder 3, to forces capable of provoking oscillations of said motor-compressor assembly transversal to said travel direction of the piston 2.

According to the present invention, in order to avoid transversal oscillations which may approximate the motor-compressor assembly to the walls of the hermetic shell 1, the suspension arms 20 are made resistant to traction and compression movements and have enough flexibility to avoid, by minimizing the occurrence of vibrations of the motor-compressor assembly in the travel direction of the piston, the oscillations of this motor-compressor assembly in the directions transversal to said travel direction.

In the illustrated construction, the motor-compressor assembly is mounted inside the hermetic shell 1 through two suspension arms 20, each having a first end 21, to be mounted to said hermetic shell 1, and a second end 22, to be mounted to an end portion of the cylinder, for example outside the motor-compressor assembly, so that said mounting to the cylinder 3

defines a mounting axis, coinciding with the axis of the piston 2 and that said mounting to the hermetic shell 1 determines an alignment of the first ends 21, according to a direction parallel to the axis of the piston 2.

In the construction illustrated in figures 2 and 3, the suspension arms 20 are flat, in the form of flexible plates of reduced thickness in the travel direction of the piston 2 and parallel to each other, each plate being formed, for example, by a pair of metallic blades spaced from each other by an elastomeric material, such as rubber.

In a way of carrying out the present invention, for the suspension arms 20, as illustrated in figure 3, each plate has, in its second end 22, a throughbore 23, which permits the introduction of a fixation element, such as a screw, for mounting said plate to the motor-compressor assembly. In the construction illustrated in figure 2, the mounting of the suspension arms 20 to said motor-compressor assembly occurs by affixing the second end 22 of one of the suspension arms 20 to the cylinder head, while the other of said suspension arms 20 is affixed to the cylinder 3, outside the resonant spring 9.

Although not illustrated, the present invention further allows, for example, mounting the motor-compressor assembly to the hermetic shell through three or more suspension arms 20 angularly provided in relation to each other and aligned in relation to the travel direction of the piston 2, on the same side of the motor-compressor assembly, or each suspension arm 20 being mounted to one side of said motor-compressor assembly, for example, on the same plane transversal to the travel direction of the piston 2, or diagonally spaced in relation to said travel direction.

In order to minimize vibrations, each metallic blade may be further coated with an elastomeric material.

CLAIMS

1. A reciprocating compressor driven by a linear motor, having a motor-compressor assembly, which is mounted suspended inside a hermetic shell (1) and includes a piston (2) reciprocating inside a cylinder (3) and impelled by an actuator (4) which sustains a magnetic component (5) impelled by the linear motor, characterized in that it comprises at least two suspension arms (20), mounted to the hermetic shell (1) and to the cylinder (3) and provided spaced from each other and transversal in relation to the travel direction of the piston, each suspension arm (20) having, in the travel direction of the piston (2), enough flexibility to minimize the transference of vibrations from the motor-compressor assembly to the hermetic shell (1) and, in the directions transversal to said travel direction of the piston (2), enough rigidity to avoid oscillations of the motor-compressor assembly in said transversal directions.

2. A reciprocating compressor, as in claim 1, characterized in that the suspension arms (20) are spaced from each other, in the travel direction of piston (2), by a distance sufficient to avoid that regions of the motor-compressor assembly external to the suspension arms (20) be subjected to forces capable of provoking oscillations of said motor-compressor assembly in a direction transversal to said travel direction of the piston 2.

3. A reciprocating compressor, as in claim 2, characterized in that the suspension arms (20) are mounted to the cylinder (3), in order to define a mounting axis coinciding with the axis of the piston (2).

4. A reciprocating compressor, as in claim 3,

characterized in that each suspension arm (20) is mounted to an external end portion of the motor-compressor assembly.

5. A reciprocating compressor, as in claim 3, characterized in that the suspension arms (20) are flat and mounted parallel to each other.

6. A reciprocating compressor, as in claim 5, characterized in that each suspension arm (20) is mounted to the hermetic shell (1) by a respective first end (21), so that the first ends (21) of two suspension arms (20) are aligned to each other according to a direction parallel to the axis of the piston (1).

7. A reciprocating compressor, as in claim 6, characterized in that the suspension arms (20) are in the form of plates of reduced thickness in the travel direction of the piston (2).

8. A reciprocating compressor, as in claim 7, characterized in that each suspension arm (20) comprises at least one pair of metallic blades spaced from each other by an elastomeric material.

9. A reciprocating compressor, as in claim 7, characterized in that each suspension arm (20) comprises a metallic blade coated with an elastomeric material.

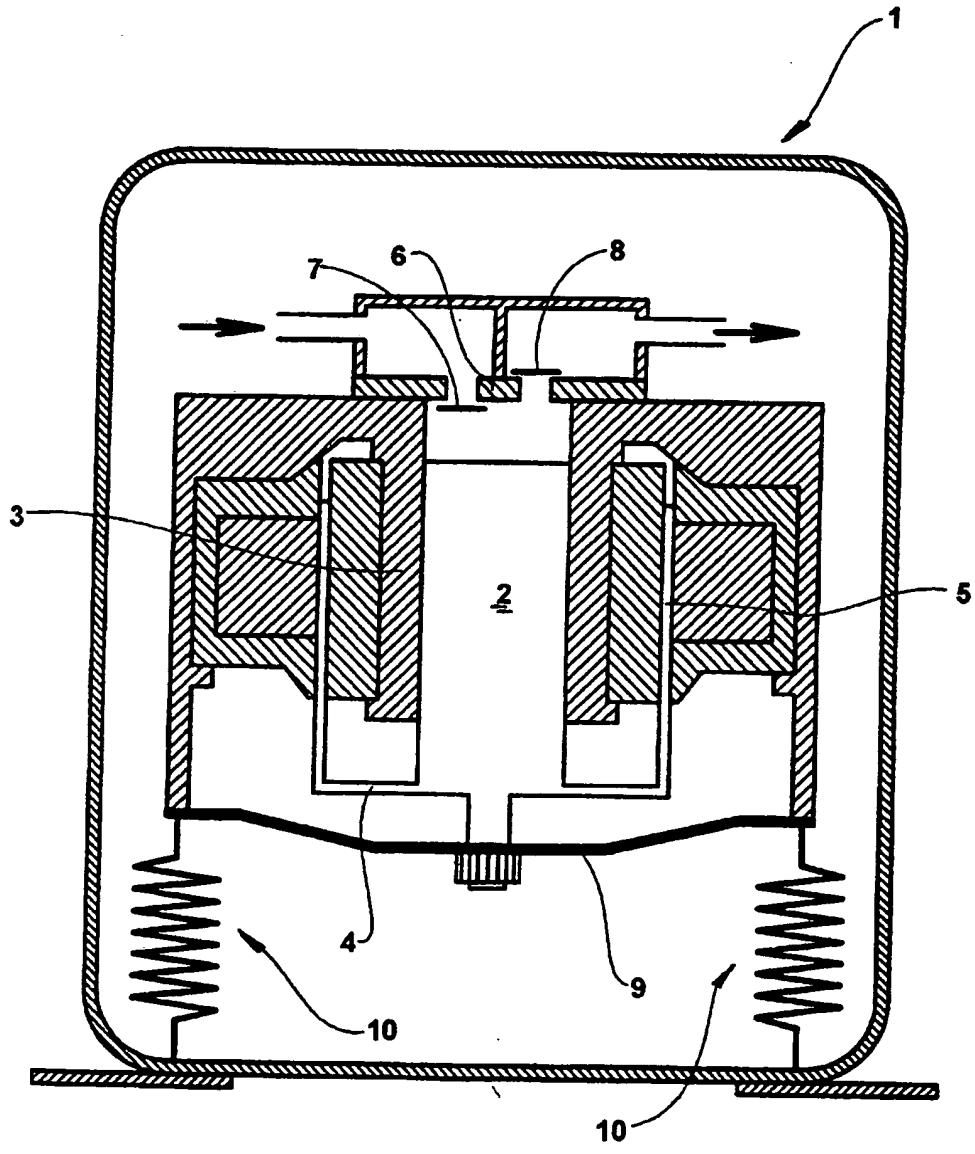


FIG.1
PRIOR ART

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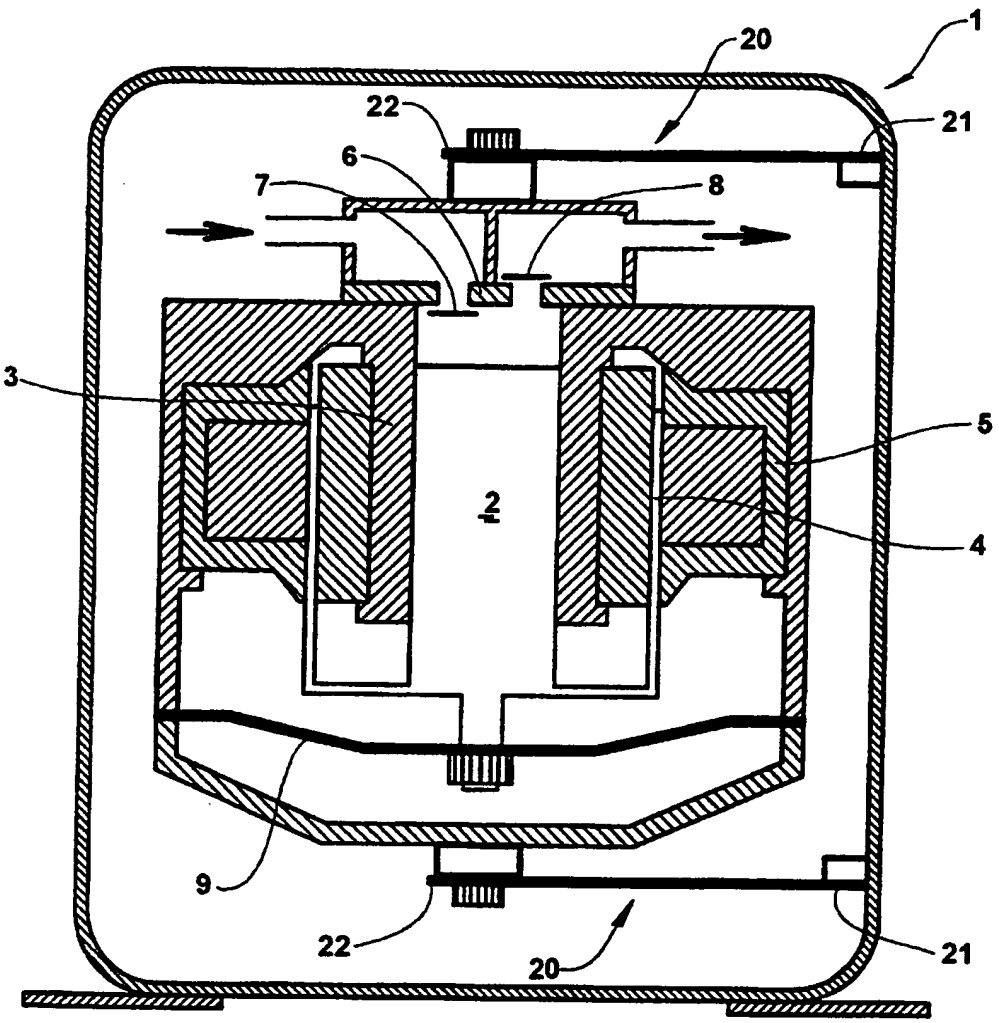


FIG.2

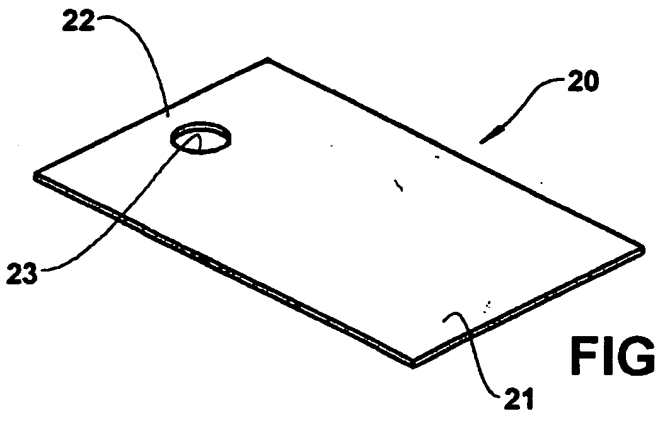


FIG.3

# INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F04B35/04 F04B39/12

According to International Patent Classification (IPC) or to both national classification and IPC

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| X | GB 1 222 425 A (N V PHILIPS' GLOEILAMPENFABRIEKEN)<br>10 February 1971 (1971-02-10)<br>page 2, line 1 - line 100; figures 1-5 | 1-7 |
| A | US 5 772 410 A (CHANG KEUN SIK)<br>30 June 1998 (1998-06-30)<br>cited in the application<br>column 3, line 60 -column 5, line 35;<br>figure 1 | 1 |
| A | US 4 416 594 A (ICHIKAWA KAORU)<br>22 November 1983 (1983-11-22)<br>column 3, line 8 -column 4, line 48;<br>figure 2 | 1 |

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|---|---|---|---|
| GB 1222425 A | 10-02-1971 | NL 6703495 A | 05-09-1968 |
| | | DE 1628175 A | 08-07-1971 |
| | | ES 351164 A | 16-05-1969 |
| | | FR 1555302 A | 24-01-1969 |
| US 5772410 A | 30-06-1998 | JP 2771799 B | 02-07-1998 |
| | | JP 9195928 A | 29-07-1997 |
| US 4416594 A | 22-11-1983 | DE 3030711 A | 26-02-1981 |